The Arizona Crisis in Physics Education: how you, the school principal, can help

June 2017

At a time when students are being encouraged to pursue a STEM career path, high school physics enrollment in Arizona is only half of the national average. This document explains why, without physics, an Arizona student's success in post-high school STEM education is in jeopardy – and how you can improve the situation.

Why *should* more students take high school physics?

Students who take an upper-level sequence of science courses that includes physics are substantially more likely to reach the College Readiness Benchmark in Science (24) than students who took only Biology and Chemistry or less." (ACT 2006, p. 3. 45% are ready vs ~20%. http://files.eric.ed.gov/fulltext/ED493179.pdf)

Physics, more than any other subject in high school, teaches quantitative and analytical reasoning skills. Math is an important tool, but physics makes math "make sense".

Physics is a gateway course for post-secondary study in science, medicine, and engineering, as well as an essential component in the formation of students' scientific literacy." (Position Statement of the National Alliance of Black School Educators - 2012)

Most leakage from the STEM career "pipeline" occurs in high school and in the transition from high school to college, not in college. Most students who do not /cannot take high school physics never enter the STEM pipeline.

Nationally the numbers of high school students taking physics has grown rapidly to 40%. Unfortunately Arizona has moved in the opposite direction. Physics enrollment is below 20% and not even offered in some large high schools because of a lack of qualified staff. The high salaries offered by industry have created an environment in which universities graduate very few physics majors who desire to teach.

Why *aren't* more Arizona students taking physics?

Monica Plisch, Associate Director of Education and Diversity at the American Physical Society, said, "Physics is often seen as an elite discipline that requires a lot of math and is only for college-bound students. This view is not only outdated, it risks underestimating students' abilities and cutting off their future opportunities in STEM".

Online guidance programs for high school students, like the MCCCD Career Guide (https://www.maricopa.edu/workforce/industry-sectors/mcccd-career-guide) are no help; they fail to recommend high school physics even for careers that clearly require physics understanding; e.g., Health Sciences, Engineering & Technology, Information Technology, etc.

Of all school subjects, physics has the most severe teacher shortage, followed by math and chemistry. There are surpluses of biology teachers.

The shortage of physics teachers leaves too many U.S. students unprepared for college study in STEM disciplines. America lags far behind most of our global competitors in physics education. The large STEM-trained populations in China and India are supporting burgeoning industrial development in those countries.

To better understand the crisis at school level, Earl Barrett and Larry Dukerich, with support of a grant from the Boeing Company in Mesa and assistance of the Arizona Department of Education, surveyed high school counselors in January 2017. Recognizing that they also needed data on students' views, they gave a similar instrument in February to chemistry students in 8 Arizona school districts. They received responses from 75 counselors and nearly 900 students.

Summary of Survey Results

1. Only 45% of chemistry students surveyed said they have a good idea of what they would study in physics. Nearly 65% of counselors think that students DO NOT have a good grasp of what physics is about.
2. While 60% of students feel that they have the math skills needed to be successful in physics, almost 70% of counselors disagree with that view.
3. About 45% of students aren't sure that physics would help them succeed in college or technical school. 57% of counselors think that students are not aware of benefits of physics.
4. Nearly 65% of students fear that a poor grade in physics will hurt their chances of being accepted by college. 56% of counselors agree.
5. More than 40% of students think that physics is only for people intending to become engineers. Over half of the counselors think this is what students believe.
6. It is distressing that nearly 60% of counselors admit that they have no significant contact with the physics teacher(s) at their school.

Conclusions

The majority of counselors believe, erroneously, that physics requires a student to have exceptional math skills and a desire to be an engineer. Without a belief that physics is important for anyone interested in a STEM career, they often steer students to other science courses. An even bigger problem is lack of an effective recruitment plan by the physics teacher: most physics teachers are in competition with their science colleagues for that third year of required science. The school seems to have no big picture that recognizes that a vibrant physics program better prepares students for a STEM career than does AP coursework. It is natural for principals to feel pressure to expand the AP program at their school because the public has been sold the idea that the number of AP offerings at a school is a measure of its academic excellence. (Charter schools like BASIS have been singled out as some of the best schools in the nation because their students take an average of 11 AP exams.) Neither parents nor students are aware that in Arizona 80% of students who take the AP-1 physics exam, for example, *fail to earn college credit* because our universities demand a score of 4 or 5 on the exam. This AP model does not work for the majority of our students.

What can be done at school level to address this crisis?

- Most of our schools could add two or more sections of physics with their present staffing.
- School districts already have the right to declare that physics has enough mathematics to be accepted as meeting the mathematics requirement for graduation. We believe students would be eager to take a class where math is applied in a real world context as their 4th required math class.
- Our survey revealed that counselors overwhelming agreed they would support physics for the average student if the class was designed to improve students' math skills and was built around practical applications and a project-based design.
- **ASU is the birthplace of a world-renowned program in the reformed practice of teaching physics – Modeling Instruction. Each summer it offers workshops and content courses that would enable your present staff to retrain and earn certification as physics instructors. The recently signed Arizona Senate Bill 1038 helps to defray the cost of such coursework, with $2000 grants to teachers.** With additional funding from school districts, it is possible to retrain a teacher for physics in as little as two summers and a school year of "refresher" evening classes. Information: http://modeling.asu.edu

We would be glad to provide our surveys. If you want to examine them closely, we can share actual counselor comments and survey results for all questions. We would be pleased to meet with you to answer your questions about implementing a plan to increase physics enrollment in your school.

Larry Dukerich ldukerich@mac.com

Earl Barrett ejbarrett10@gmail.com

Larry Dukerich received his B.S. in Chemistry from Michigan State University and his Master of Natural Science degree from Arizona State University. He taught high school chemistry and physics, including regular, honors and AP courses, in Michigan and Arizona for 34 years. He was a Woodrow Wilson Dreyfus Fellow in Chemistry in 1986 and a Presidential Awardee for Excellence in Science Teaching in 2000. Since 1995, he has conducted numerous summer workshops for physics and chemistry teachers as part of the Modeling Instruction Program at ASU, and later in Pennsylvania, N Carolina, Tennessee, New York City, Missouri, California and Colorado. He has made presentations about and conducted workshops on Modeling Instruction at NSTA, ChemEd and BCCE conferences. He is a lead contributor to the curricular materials used in Modeling Instruction in chemistry.

Earl Barrett received his B.S. in Science from Seton Hall University and his MST from Antioch College. He taught high school earth science, biology, chemistry and physics, including regular, honors, dual enrollment and AP courses, in New Jersey and Arizona for 41 years. He has participated in National Science Foundation graduate study institutes in mathematics, earth science, and physics at Rutgers University, Newark College of Engineering, NC State, UC Berkeley, ASU, Florida State, Colorado State, Dartmouth College, Dickinson College and Lewis and Clark College. He served two years as the president of the Phoenix Union High School District classroom teachers association and treasurer of the Arizona Science Teachers Association. He was a nominee for Teacher of the Year in 1987, received a Presidential Award for Excellence in Science Teaching in 1993, and was a recipient of the Tandy Technology Outstanding Teacher Award as a Top Fifty Physics teacher in 1990. Since retiring he has given local presentations concerning the crisis in physics education and had a related paper published in The Physics Teacher. https://www.aapt.org/Resources/upload/PTE000399_Increasing-Physics-Enrollment.pdf

Together they taught physics and chemistry at Dobson High School in Mesa, AZ for 20 years.